International Journal of Science Engineering and Advance Technology

Performance and Analysis Of Modern Soot Blower By Improving Boiler Efficiency Of A Thermal Power Plant

Mortha Babji[1] P.Satish Reddy[2*] N.Guru Murthy[3] M Manoj[4]
PG Scholar, Assoc. Professor, Asst Professor, Asst Professor
Dept of Mechanical Engineering, Prasiddha College of Engg & Tech, Amalapuram
babjimech303@gmail.com,satish2436@gmail.com,murthy408@gmail.com,mattamanoj13@gmail.com

ABSTRACT:

In Thermal power plants for better performance and maximum efficiency the best suitable method is Energy Audit, which plays a key role in any industry or organization. Every problem has a solution; we have so many ways to solve a problem but choosing a best method, give better results and save the time and money which is possible by energy audit. In this thesis to accomplish the task, KTPS 500MW Thermal power plant is selected. Here the maximum boiler efficiency is 78% at full load operating conditions. To know the reason behind this reducing the boiler efficiency, conducted an audit and identified the main losses. After analyzing all losses the major one is heat loss due to dry flue gas, which is nearly 12% compared to remaining losses.

The main reason behind this loss is, there is no proper heat transfer between flue gas and feed water contained in the economizer coil, after combustion of coal the flue gases are released at the same time soot also liberated and it is largely placed at the top of the boiler in the surface of economizer coil. To remove that soot on the economizer coil surface present in KTPS they use some soot blowers but they are not achieving the better results as well as operating and maintaining cost is very high.

Main motto of this thesis is to develop a modern soot blower with less operating cost and achieve better results. The main important change in this advanced blower is change in the working medium. In the present soot blower the working medium is steam. It means by using boiler output they are running the present soot blower still not obtaining good results and at the same time losing the boiler efficiency. In the modern soot blower the working medium is hot air so without using the output of boiler, run this modern designed soot blower at the same time the soot is totally removed from the surface of economizer coil and the loss due to dry flue gas is reduced up to 4%. So boiler efficiency is improved and have a chance to economic benefit also by using this modern designed soot blower because of its working medium and less operating cost.

Key words: ***Energy audit, Boiler efficiency, Heat loss calculations, Soot blowers.***

I.INTRODUCTION:

Around 70% of vitality era limit is from petroleum derivatives in India. Coal utilization is 40% of India's aggregate vitality utilization which took after by unrefined petroleum and flammable gas at 24% and 6% individually. India is reliant on petroleum product import to satisfy its vitality requests. The vitality imports are required to surpass 53% of the India's aggregate vitality utilization. In 2009-10, 159.26 million tons of the unrefined petroleum is foreign made which adds up to 80% of its residential raw petroleum utilization. The rate of oil imports are 31% of the nation's aggregate imports. The request of power has been prevented by residential coal deficiencies. Reason for this current, India's coal imports is expanded by 18% for power era in 2010. India has one of the world's quickest developing vitality advertises because of fast financial extension. It is relied upon to be the second biggest supporter of the expansion in worldwide vitality request by 2035. Vitality request of India is expanding and constrained household non-renewable energy source holds[1].

The nation has goal-oriented arrangements to grow its sustainable power source assets and arrangements to introduce the atomic power ventures. India has the world's fifth biggest wind control market and plans to include around 20GW of sun oriented power limit. India builds the commitment of atomic energy to general power era limit from 4.2% to 9%. The nation has five atomic reactors under development. Presently India turned out to be third most astounding on the planet who is producing the power by atomic and arrangements to develop 18 extra atomic reactors by 2025, then India will turn out to be second most noteworthy on the planet[2].

Execution of heater like effectiveness and vanishing proportion decreases with time, because of poor burning, warm exchange fouling and poor operation and upkeep. Disintegration of fuel amount and water quality likewise prompts poor execution of kettle. Proficiency testing helps us to discover how far the kettle effectiveness floats away from the best productivity. Any watched unusual deviations could along these lines be examined to pinpoint the issue zone for fundamental restorative activity. Thus it is important to discover the present level of proficiency for execution assessment, which is a pre essential for vitality protection activity in industry[3].

II.HEAT LOSS CALCULATIONS

DIRECT METHOD

To find out the boiler efficiency the direct method is adopted because it is very easy method uses simple calculations and the data readily given by the instruments.

Type of Boiler under test: Coal fired Boiler

Heat output data

Quantity of steam generated (output): **1685 TPH**

Steam pressure:**185.49 bar**

Enthalpy of steam (dry & Saturated) at 10 kg/cm^2 (g) pressure: **831.34 Cal/kg**

Feed water temperature: **264.6^0 C**

Enthalpy of feed water: **285.31 Cal/kg**

Heat input data

Quantity of coal consumed (Input): **290 TPH**

GCV of coal: **3482 Cal/kg**

Boiler Efficiency = $\frac{Q(H-h)}{q \times GCVofCoal} x\ 100$

Where **Q** = Quantity of steam generated per hour (kg/hr.)

q = Quantity of fuel used per hour (kg/hr.)

GCV = Gross calorific value of the fuel (Cal/kg)

H = Enthalpy of steam (Cal/kg)

h = Enthalpy of feed water (Cal/kg)

Boiler Efficiency (η) $= \frac{Q(H-h)}{q \times GCVofCoal} x\ 100$

$$\frac{1685000 \times (831.34 - 285.31)}{290000 \times 3482} x100$$

=91.11% [4]

III. INDIRECT METHOD TESTING

The proficiency can be measured effortlessly by measuring every one of the misfortunes happening in the boilers utilizing the standards to be portrayed. The disservices of the immediate strategy can be overcome by this technique, which ascertains the different warmth misfortunes related with heater. The effectiveness can be touched base at, by subtracting the warmth misfortune portions from 100.An essential preferred standpoint of this strategy is that the mistakes in estimation don't roll out huge improvement in proficiency.[5]

CALCULATIONS FOR LOSSES OF BOILER (Without Soot Blower):

Without soot blower the average flue gas temperature = 240ºC

Ambient Temperature = 35.54 ºC

1. % HEAT LOSS DUE TO DRY FLUE GAS:-

$$L_1 == \frac{m \times C_p \times (T_f - T_a)}{GCV\ of\ Fuel} x100$$

$$= \frac{7.543 \times 0.23 \times (240 - 35.54)}{3482} x100$$

= 11.5%

2. % HEAT LOSS DUE TO EVAPORATION OF WATER FORMED DUE TO H_2 IN FUEL:-

$$L_2 = \frac{9 \times H_2 \times \{584 + C_p \times (T_f - T_a)\}}{GCV\ of\ Fuel} x100$$

$$= \frac{9 \times 0.027 \times \{584 + 0.54 \times (240 - 35.54)\}}{3482} x100$$

= 4.71%

3. % HEAT LOSS DUE TO MOISTURE PRESENT IN FUEL:-

$$L_3 = \frac{M \times \{584 + Cp \times (T_f - T_a)\}}{GCV\ of\ Fuel} x100$$

$$= \frac{0.09 \times \{584 + 0.45 \times (240 - 35.54)\}}{3482} x100$$

= 1.74%

4. %HEAT LOSS DUE TO MOISTURE PRESENT IN AIR:-

$$L_4 = \frac{AAS\ x\ Humidity\ factor x C_p\ x\ (T_f - T_a)}{GCVOfFuel} x100$$

$$= \frac{8 \times 0.0204 \times 0.45 \times (240 - 35.54)}{3482} x100$$

0.43%

5. % HEAT LOSS DUE TO INCOMPLETE COMBUSTION:

$$L_5 = \frac{\%CO \times C}{\%CO + \%co_2} x \frac{5744}{GCV\ of\ fuel} x100$$

$$= \frac{0.55 \times 0.400}{0.55 + 14} x \frac{5744}{3482} x100$$

= 2.92%

6. HEAT LOSS DUE TO RADIATION AND CONVECTION:

L_6=0.548 x [(Ts / 55.55)^4 – (Ta / 55.55)^4] + 1.957 x (T_s – T_a) 1.25 x sq.rt of [(196.85 Vm + 68.9) / 68.9]

= 0.52 %

7. HEAT LOSS DUE TO UN BURNT FUEL IN FLY ASH (%):

$$L_7 = \frac{\text{Total ash collected per kg of fuel x GCV of fly ash}}{\text{GCV of fuel}} x100$$

% Ash in Coal = 36%
Ratio of Bottom Ash to Fly Ash = 5:10
GCV of Fly Ash = 452.5 kcal/kg
Amount of Fly Ash = 0.1×0.36 = 0.036
Heat Loss in Fly Ash = 0.036×452.5 = 16.29[6]
$L7$=16.29/3482×100
= 0.4678%

8. HEAT LOSS DUE TO UN BURNT FUEL IN BOTTOM ASH (%):

$$L8 = \frac{\text{Total ash collected per kg of fuel x GCV of bottom ash}}{\text{GCV of fuel}} x100$$

GCV of Bottom Ash = 800 k Cal/kg
Amount of bottom ash in kg of coal = 0.5×0.36 = 0.18

Heat Loss in Bottom Ash = 0.18×800 = 144
%$L8$=1443482×100
= 4.135% [7]

Total Losses:

S.NO	LOSSES	% OF LOSS
1	LOSS 1	11.50
2	LOSS 2	4.71
3	LOSS 3	1.74
4	LOSS 4	0.43
5	LOSS 5	2.92
6	LOSS 6	0.53
7	LOSS 7	0.4678
8	LOSS 8	4.135

Table: 2.1 % of Various Losses without Soot blower

Total Losses Total Losses =$L1+L2+L3+L4+L5+L6+L7+L8$ =(11.5+4.71+1.74+0.4322+2.92+0.53+0.4678+4.135) %
= 26.43%

Boiler Efficiency by Indirect Method (without soot blower)=100−(% *Total Loss*
=100−(26.43%)
= 73.56%

III.BOILER EFFICIENCY BY INDIRECT METHOD (WITH EXISTING SOOT BLOWER):

With soot blower the average flue gas temperature = 190ºC
Ambient Temperature = 35.54 ºC
Blowing Medium = Steam

1. % HEAT LOSS DUE TO DRY FLUE GAS:

$$L_1 == \frac{m \times C_p \times (T_f - T_a)}{GCV\ of\ Fuel} x100$$

$$= \frac{7.543 \times 0.23 \times (190 - 35.54)}{3482} x100$$

= 7.69%

2. % HEAT LOSS DUE TOTEL EVAPORATION OF WATER FORMED DUE TO H2 IN FUEL:

$$L2 = \frac{9 \times H_2 \times \{584 + C_p \times (T_f - T_a)\}}{GCV\ of\ Fuel} x100$$

$$= \frac{9 \times 0.027 \times \{584 + 0.45 \times (190 - 35.54)\}}{3482} x100$$

= 4.56%

3. % HEAT LOSS DUE TO MOISTURE PRESENT IN FUEL:

$$= \frac{M \times \{584 + Cp \times (T_f - T_a)\}}{GCV\ of\ Fuel} x100$$

$$L3 = \frac{0.09 \times \{584 + 0.45 \times (190 - 35.54)\}}{3482} x100$$

= 1.689%

4. %HEAT LOSS DUE TO MOISTURE PRESENT IN AIR:

$$L4 = \frac{\text{AAS X Humidity factorx} C_p\ x\ (T_f - T_a)}{\text{GCV Of Fuel} \times 100} x100$$

$$= \frac{8 \times 0.0204 \times 0.45 \times (190 - 35.54)}{3482} x100$$

5. HEAT LOSS DUE TO INCOMPLETE COMBUSTION:

$$L5 = \frac{\%CO \times C}{\%CO + \%co_2} x \frac{5744}{GCV\ of\ fuel} x100$$

$$= \frac{0.55 \times 0.400.}{55 + 14} x \frac{5744}{3682} x100$$

= 2.49%

6. HEAT LOSS DUE TO RADIATION AND CONVECTION:

L_6=0.548 x [(T_s / 55.55)^4 – (Ta / 55.55)^4] + 1.957 x (T_s – T_a) 1.25 x sq.rt of [(196.85 Vm + 68.9) / 68.9]
= 0.49 %

7. HEAT LOSS DUE TO UN BURNT FUEL IN FLY ASH (%):

$$L_7 = \frac{\text{Total ash collected per kg of fuel x GCV of fly ash}}{\text{GCV of fuel}} x100$$

% Ash in Coal = 36%
Ratio of Bottom Ash to Fly Ash = 5:10
GCV of Fly Ash = 452.5 kcal/kg
Amount of Fly Ash = 0.1×0.36
= 0.036
Heat Loss in Fly Ash = 0.036×452.5 = 16.29
$L7$=16.29/3482×100
= **0.4678%**

8. HEAT LOSS DUE TO UN BURNT IN BOTTOM ASH (%):

$$\frac{\text{Total ash collected per kg of fuel x GCV of bottom ash}}{\text{GCV of fuel}} x100$$

GCV of Bottom Ash = 800 k Cal/kg

Amount of bottom ash in kg of coal = 0.5×0.36 = 0.18

Heat Loss in Bottom Ash = 0.18×800 = 144

%$L8$=144/3482×100

= 4.135%

Total Losses:

S.NO	LOSSES	% LOSS
1	LOSS 1	7.69
2	LOSS 2	4.56
3	LOSS 3	1.689
4	LOSS 4	0.325
5	LOSS 5	2.49
6	LOSS 6	0.49
7	LOSS 7	0.4678
8	LOSS 8	4.135

Table: 3.1 % of Various Losses with Existing soot blower

Total Losses Total Losses =$L_1+L_2+L_3+L_4+L_5+L_6+L_7+L_8$

=(7.69+4.56+1.689+0.325+2.49+0.49+0.4678+4.135) %

= 21.846% Soot Blower

Boiler Efficiency by Indirect Method (without soot blower)=100−(% $Total\ Losses$)

=100−(21.84%)

= 78.15%

IV.BOILER EFFICIENCY BY INDIRECT METHOD (WITH MODERN SOOT BLOWER):

1.% HEAT LOSS DUE TO DRY FLUE GAS:-

$$L1 = \frac{m\times C_p\times(T_f-T_a)}{GCV\ of\ Fuel} x100$$

$$= \frac{7.543\times0.23\times(120-35.54)}{3482} x100$$

= 4.208%

2. % HEAT LOSS DUE TO EVAPORATION OF WATER FORMED DUE TO H_2 IN FUEL:-

$$L2=\frac{9\times H_2\times\{584+C_p\times(T_f-T_a)\}}{GCV\ of\ Fuel} x100$$

$$\frac{9\times0.027\times\{584+0.45\times(120-35.54)\}}{3482} x100$$

= 4.34%

3. % HEAT LOSS DUE TO MOISTURE PRESENT IN FUEL:-

$$L3=\frac{M\times\{584+Cp\times(T_f-T_a)\}}{GCV\ of\ Fuel} x100$$

$$= \frac{0.09\times\{584+0.45\times(120-35.54)\}}{3482} x100$$

= 0.670%

4. %HEAT LOSS DUE TO MOISTURE PRESENT IN AIR:-

$L4$=

$$\frac{\text{AAS x Humidity factor}x C_p\ x\ (T_f-T_a)}{\text{GCV of fuel}\times100} x100$$

$$\frac{8\times0.0204\times0.45\times(120-35.54)}{3482} x100$$

= 0.178%

5. HEAT LOSS DUE TO INCOMPLETE COMBUSTION:

$$L5=\frac{\%CO\times C}{\%CO+\%co_2}\ x\ \frac{5744}{GCV\ of\ fuel} x100$$

$$L5=\frac{0.55\times0.400.}{55+14}\ x\ \frac{5744}{3682} x100$$

= 2.49%

6. HEAT LOSS DUE TO RADIATION AND CONVECTION:

L_6 = 0.548 x [(T_s / 55.55)^4 – (Ta / 55.55)^4] + 1.957 x (T_s – T_a) 1.25 x sq.rt of [(196.85 Vm + 68.9) / 68.9]

= 0.43%

7. HEAT LOSS DUE TO UN BURNT IN FLY ASH (%):

$$\frac{\text{Total ash collected per kg of fuel x GCV of fly ash}}{\text{GCV of fuel}} x100$$

% Ash in Coal = 36%

Ratio = 50:10

GCV of Fly Ash = 452.5 kcal/kg

Amount of Fly Ash = 0.1×0.36 = 0.036

Heat Loss in Fly Ash = 0.036×452.5 = 16.29

$$L7=\frac{16.29}{3482} x100$$

= 0.4678%

8. HEAT LOSS DUE TO UN BURNT IN BOTTOM ASH (%):

$L8$=

$$\frac{\text{Total ash collected per kg of fuel x GCV of bottom ash}}{\text{GCV of fuel}} x100$$

GCV of Bottom Ash = 800 k Cal/kg

Amount of bottom ash in kg of coal = 0.5×0.36 = 0.18

Heat Loss in Bottom Ash = 0.18×800 = 144

%$L8$=1443482×100 = **4.135%**

Total Losses:

S.NO	LOSSES	% Of LOSS
1	LOSS 1	4.208
2	LOSS 2	4.34
3	LOSS 3	1.670
4	LOSS 4	0.178
5	LOSS 5	2.41
6	LOSS 6	0.43
7	LOSS 7	0.4678
8	LOSS 8	4.135

Table: 4.1 % of various losses with modern soot blower

Total Losses $=L1+L2+L3+L4+L5+L6+L7+L8$
$=(4.208+4.34+1.670+0.178+2.41+0.43+0.4678+4.135)\ \%$
= 17.83%
Boiler Efficiency by Indirect Method (without modern soot blower)=100−(% $Total\ Losses$)
=100−(17.83%) = 82.16%
Efficiency of modern Soot Blower (η) = **82.16%**

V.RESULTS AND DISCUSSIONS:

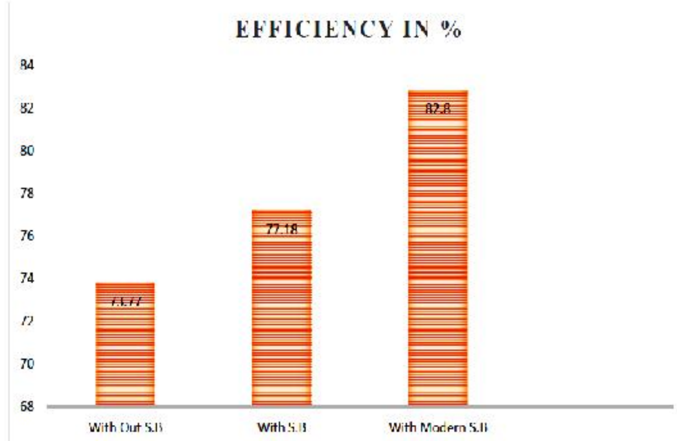
EFFICIENCY COMPARISON BETWEEN WITHOUT SOOT BLOWER, WITH EXISTING SOOT BLOWER AND WITH MODERN SOOT BLOWER:

Efficiency Comparison Graphs:

This graph is drawn between Different efficiencies that is Efficiency at without soot blower, Efficiency at with soot blower, Efficiency at modern soot blower from these graphs main observations are listed in the table [8]

Type	**Efficiency**
Without soot blower	73.77%
With existing soot blower	77.18%
With Modern Soot Blower	82.16%

Table: 5.1 Efficiency comparison for without soot blower, with existing soot blower and modern soot blower.



Graph:5.1 Efficiency comparison for without soot blower, with existing soot blower and modern soot blower**.**

VI.VARIABLE LOSS COMPARISON FOR WITHOUT, WITH, MODERN SOOT BLOWER:

This graph is plotted between over losses at different conditions i.e. without soot blower condition and with soot blower condition and modern soot blower condition. **.** From these graphs main observations are listed in the table

Type	Loss 1	Loss 2	Loss 3	Loss 4	Loss 5	Loss 6	Loss 7	Loss 8
Without soot blower	11.5	4.85	1.79	0.58	2.49	0.53	0.47	4.14
With soot blower	7.61	4.56	1.69	0.33	2.49	0.49	0.47	4.14
Modern soot blower	4.2	4.34	1.67	0.18	2.49	0.43	0.47	4.14

Table 6.1 All the losses with various types of soot blowers

Chart: 6.1All the misfortunes with different sorts of ash blowers

L1-Loss because of dry pipe gas (sensible warmth)

L2-Loss because of hydrogen in fuel (H2)

L3-Loss because of dampness in fuel (H2O)

L4-Loss because of dampness in air (H2O)

L5-Loss because of carbon monoxide (CO)

L6-Loss because of surface radiation, convection and other UN accounted

L7-Un consumed misfortunes in fly cinder (Carbon)

L8-Un consumed misfortunes in base cinder (Carbon)

VII. Conclusion:

By using the modern soot blower the heat loss due to dry flue gas can be reduced by 4.20% by means of the reducing the heat loss due to dry flue gas, the efficiency of the boiler can be increased to 82.8% and more over by using this modern soot blowers we can reduce the no of soot blowers used in boiler.(present used 44 Long retractable soot blowers) Because of low speed motor and high cost input i.e. steam and important lance length is not good, in modern soot blower lance length is increased and medium used is hot air .It is very cheap and easily available from the atmosphere. We used 16 soot blowers to manage the entire boiler and maintenance is very low compared to existing one which has economical benefit also.

From the Graphs un-burnt losses in bottom ash and fly ash are not changed because of improper combustion. This is due to low GCV of Fuel i.e. Coal. By using high GCV of Coal in Semi bituminous form the performance of the boiler can be improved to a great value, but it is economically high. At present the plant is using Indian Ignite coal of F grade which of its GCV is 3482 k Cal/kg and percentage ash in the coal is 36%. The GCV of semi bituminous coal is 5800 k al/kg and percentage ash in coal is 12.1%.[9]

VIII. FUTURE SCOPE

The technology used in reducing the loss of the boiler is not economical to the existing one why because all the equipment is already installed and too costly to change it but use of this technology in new plants have a possibility to save the money at the same time achieve maximum efficiency of boiler. Maintain audit in each and every department from low level to high level there is a chance to reduce the maintenance and operating cost of the plant so there is a possibility to use high grade Semi bituminous coal with that reducing cost. Use of this high grade coal there is a chance to reduce maximum losses and run the overall plant with maximum profits.

IX. REFERENCES

1.Pankaj Sindu, Somvir Arya, " A Energy Audit Thermal Power Plant" International Journal of Exploring Emerging Trends In Engineering, Vol.01, Issue 03, Nov 2014.

2. Chetan Patel T, Dr.Bhavesh Patel K, Vijay Patel K, " Efficiency with Different Gcv Of Coal And Efficiency Improvement Opportunity In Boiler" International journal of innovative research in Science, Engineering and Technology, Vol. 2, Issue 5, May 2013

3. Vikas Duhan, Jitender Singh, "Energy Audit of Rajeev Gandhi Thermal Power Plant Hisar"
International Journal for research Publication & seminar, Vol 05, Issue 02, March 2014

4. Moni Kuntal Bora, Nakkeeran S, "Performance Analysis from the Efficiency Estimation of Coal Fired Boiler" International Journal of Advanced Research, Vol. 2, Issue 5, Pg. 561-574.

5. Kaliazine A, Cormack D E, Tran H and Jameel I, "Feasibility of using low pressure steam for soot blowing", Pulp & Paper, Energy Conservation, Vol.107.4, 2006, Pg.34.

6.Amit Kumar Jain, " An Optimal Preventive Maintenance Strategy for Efficient Operation of boiler in industry" International Institute for Science Technology and Education, Vol 02, Issue 04, 2012.

7. Gaurav T. Dhanre, Urvashi T. Dhanre, Krunal Mudafale, "Review Paper on Energy Audit of a Boiler in Thermal Power Plant" International Journal of Engineering Research and General Science Volume 2, Issue 6, October-November, 2014.

8. Venkata Seshendra Kumar Karri, "A Theoretical Investigation of Efficiency Enhancement in Thermal Power Plants" Modern Mechanical Engineering, 2012, 2, 106-113.

9. Namdeo D. Adate & R. N. Awale, "Energy Conservation through Energy Efficient Technologies at Thermal Power Plant" International Journal of Power System Operation and Energy Management ISSN 2231 – 4407, Vol-2, Issue-3, 4.